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ABSTRACT

To gain a better understanding of visual perception in reading, a study tested the predictive validity of the Goodman Model of Reading by measuring the extent to which 82 college students (graduate and undergraduate) were able to perceive and accurately report 10 lines of print. It also attempted to integrate research conducted over the past 100 years using the tachistoscope with current knowledge of perception in reading. Results indicated that visual perception is affected by, but not limited to, what is visually available and that perceivers' cognitive schema are actively involved in the perception of visual information. Findings also showed that subjects' knowledge of the redundancy of language enhanced perception and allowed for more efficient, accurate, and complete visual perception. Analyses showed that an English sentence was perceived more accurately than an English word, that a word was perceived more accurately than a "pseudoword," and that a pseudoword was perceived more accurately than a line with an unnatural word order. In short, the more a line approximated written English, the more accurately it was reported. (Statistical tables and a four-page list of references are included. An appendix lists the lines of print in the form and sequence of their presentation in the study.) (JD)

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Perception in a Psycholinguistic Model of the Reading Process

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A Research Report

July, 1984 No. 11

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Table of Contents

Abstract 2

Perception and a Psycholinguistic Model of Reading 3

Tachistoscopic Research 5

Design of the Study 10

Methodology 12

Subjects 12

The Lines of Print and Their Presentation 13

Scoring Subjects' Responses 14

Analysis of Data 16

Prediction of Performance 16

Findings 18

Discussion 23

References 26

Appendix - The Lines of Print in the Form and Sequence of Presentation 30

List of Tables

Table 1 - Summary of Groupings for Analysis 17

Table 2 - Mean Accuracy Scores for Each Line of Print 19

Table 3 - T-test Between Accuracy of Reports for English Sentence and Accuracy of Reports for English Word 20

ABSTRACT

This study investigated the nature of visual perception of lines of print during a single fixation. It also worked to integrate research over the past hundred years which used a tachistoscope with current knowledge of perception in reading. The findings of this study indicate that visual perception is affected by, but not limited to, what is visually available. The perceiver's cognitive schemata are actively involved in the perception of visual information. The perceiver's knowledge of the redundancy of language enhances perception and allows for visual perception that is at once more efficient and more accurate and complete. In the study an English sentence was perceived more accurately than an English word; the word was perceived more accurately than a pseudoword; the pseudoword was perceived more accurately than a line with an unnatural word order. The more a line approximated written Engish, the more accurately it was reported.

Perception and a Psycholinguitic Model of Reading

Reading cannot occur without visual perception, so issues concerning the nature of perception in the reading process have been of interest to researchers and theoreticians for the last hundred years. Investigators have attempted to understand how we perceive when we read so that a greater understanding of both the reading process and the human mind may be gained.

These attempts to understand reading have represented a major research effort since the last decade of the nineteenth century. In 1908, E.B. Huey said that a complete analysis of what we do when we read would be almost "the acme of a psychologist's achievements" (Huey, 1968, p.6).

Since 1908, research aimed at understanding the reading process has been both numerous and diverse; theories of the reading process have been developed based on that research; models of reading based on those theories have been advanced; further research to test as well as to refine those theories and models has been conducted. Controversy and debate still surround attempts to "completely analyze what we do when we read" (Huey, 1968, p. 6).

As early as 1967 Goodman advanced a theory of the reading process based on a perspective drawn from the discipline of psycholinguistics, the study of the relationship between thought and language. According to this theory, perception is not strictly limited to what is visually available but also depends on the expectations and linguistic and cognitive inputs of the reader. Indications of the nature of the perceptual process in reading can be drawn from the research of Goodman and others (Goodman, 1973; Goodman, 1982; Goodman and Burke, 1973; Goodman and Goodman, 1977; Gollasch, 1980).

Studies such as those cited above lead to the conclusion that visual perception when reading connected discourse has several elements which must be considered:

1. such visual perception is determined in part by what is visually available.

2. such visual perception requires the cognitive input of the reader.

3. such visual perception depends on an interaction between the reader's knowledge of language and the nature of the language which is visually available.

Such conclusions, if they are valid insights into the nature of perception in reading, must also be consistent

with and explain findings from traditional research in the field of reading during the past hundred years. Among such studies is a broadly based body of research which has utilized the tachistoscope as an instrument for presenting visual material for limited periods of time for the purpose of sampling and studying visual perception (Venezky, 1977).

McConkie (1983) has pointed out that tasks involving perception of tachistoscopically presented material and normal reading are quite different. Significant differences exist in the nature of the visual stimuli and the responses called for with each mode of presentation. Yet he has conceded that tachistoscopic presentation of material and a single fixation during reading are alike in that "the visual system is exposed to a relatively stable retinal pattern for a brief period of time" (p. 66). To this extent results from tachistoscopic studies should yield patterns predictable by the psycholinguistic theory.

This present study utilized a tachistoscope as an instrument of presentation of visual material for a period of time consistent with the exposure time used in traditional studies. This study was not intended to investigate visual perception beyond a single visual fixation. It was intended instead to test the predictive validity of the Goodman Model of Reading in determining a priori the quality of the perceptions of the subjects in this study when presented with visual stimuli for such a time as to allow only one visual fixation per line of print.

Guba (1978) wrote of the process of triangulation in which investigators test one source against another until a valid interpretation can be reached. This study is part of such triangulation. It uses data from one kind of research to support or contradict conclusions drawn from very different data to understand the nature of perception in reading.

A normal rate of reading is 250 words per minute, four or five words per second (Smith, 1971). Since visual information is picked up during very brief periods of a hundredth of a second or less (Smith, 1975) and the average interval period between fixations is about a quarter of a second (Smith, 1978), the number of fixations per second is limited to approximately four. This then makes for very rapid visual perception and processing of the visual input during reading. This speed of perception and processing of visual information is similar to what must be done with tachistoscopically presented material. So the tachistoscope has potential as an instrument for sampling perception during reading.

Tachistoscopic Research

Cattell (1886) reported on experiments he performed in which visual stimuli (letters, words and pictures) were placed on a rotating drum (termed a "physiological kymograph", p. 64) and were rapidly exposed to the subjects. Cattell found that the nine subjects in his experiment were able to identify words which did not form sentences in 1/4 second per word. Yet when the words did make a sentence they were identified at a rate of 1/8 second per word. Basically Cattell found that sentences are read faster than words, words read faster than letters, letters identified faster than pictures.

Cattell also learned through his experiments that the rate at which a subject was able to read in a foreign language was directly related and proportional to the subject's familiarity with that language.

Cattell's finding that sentences are easier to read than words has been substantiated through subsequent research. Hamilton (1907) found that context was an important determining factor in word recognition:

> It also has been found that for all subjects ranging from about the age of nine or ten up to maturity the constituent elements of context, i.e., the phrase, the sentence, the paragraph, etc., have each a definite measurable value as an aid in the perception of words (p. 52).

Morton (1964) had subjects identify single words in three different settings: high probability contexts, low probability contexts, and no context. Using a tachistoscope as an instrument for presenting the settings, he was able to determine the threshold time for identifying the target word. In keeping with Cattell's findings, Morton found the threshold time for identifying the target word to be significantly lower for the two settings in which context was provided than for the word presented without a context. Further, Morton found the threshold time for identifying the target word to be significantly lower for the high probability context than for the low probability context.

Tulving and Gold (1963) examined a similar problem through the use of a tachistoscope. Sentences typed in upper case letters which provided a context for the target words were shown in the upper part of the pre-exposure field just prior to the target word being flashed. Recognition threshold levels were then determined for the target word when the pre-exposure context was relevant to the target word and when that same context was not relevant. They discovered that the target word was identified at a

significantly lower recognition threshold for relevant contexts than for non-relevant contexts. Tulving and Gold concluded that the amount of featural information needed to identify a word is directly related to the amount of contextual information available for that word, with the two sources of information being to some extent interchangeable and mutually supportive.

Cattell's finding that words are perceived more rapidly than equivalent numbers of individual letters has been well born out through several research studies (Reicher, 1969; Wheeler, 1970; Mezrich, 1973). Thompson and Massaro (1973) performed research which supported the finding that words are perceived more rapidly and accurately than individual letters, but also found that this effect could be eliminated by adequately controlling for redundancy.

The questions and specific research procedures in tachistoscopic studies have been expanded and more thoroughly examined since the time of Cattell's research.

Several research studies have compared the speed of identification of words with the speed of identification of random letter strings or orthographically legal non-words (Bryden, 1960; Chambers & Forster, 1975; Manelis, 1974; McClelland, 1976; Smith & Haviland, 1972). Throughout all such studies words have been found to be identified more rapidly and with greater accuracy than either random letter strings or orthographically legal non-words.

Chambers and Forster (1975) compared the rate of identification of high frequency words, low frequency words, orthographically legal non-words, and random letter strings. They found words to be processed faster than legal non-words and high frequency words faster than low frequency words. High frequency words, low frequency words and orthographically legal non-words were all processed faster than random letter strings.

Krueger (1970) tachistoscopically presented a target letter above a six letter word or a six letter non-word. The subjects indicated whether the word or non-word contained the targeted letter. Krueger found that subjects responded faster and more accurately for words than for non-words. That words are perceived more accurately and more rapidly than non-words has been supported by other research (Baron & Thorston, 1973; Chambers & Forster, 1975; Estes, 1975; Manelis, 1974; McClelland, 1976; Smith & Haviland, 1972; Wheeler, 1970).

Smith (1969) used a tachistoscope to test subject's perception of letters. He learned that there is a relationship between the amount of redundancy available in a

letter string and the amount of featural information necessary to identify it. The greater the redundancy the less the amount of featural information necessary for identification.

Shannon (1948) devised a method of determining the amount of redundancy and entropy found in printed English. Shannon defined redundancy as a measure of "the amount of constraint imposed on a text in the language due to its statistical structure" (Shannon, 1951, p. 50). Entropy was defined as "a statistical parameter which measures, in a certain sense, how much information is produced on the average for each letter of a text in the language" (p. 50). Miller, Bruner and Postman (1954) used Shannon's method of determining redundancy and entropy in a study which examined the subject's ability to perceive tachistoscopically presented approximations to words. The pseudowords used in the study were constructed by using a procedure outlined by Shannon (1951).

The pseudowords were grouped according to their degree of approximation to English, ranging from zero-order with no approximation to English spelling to fourth-order with a relatively high degree of approximation to English spelling. The pseudowords were then presented by the use of a tachistoscope for differing lengths of exposure duration. Miller, Bruner and Postman (1954) reported that "The most nonsensical pseudowords (zero-order) yield the lowest scores, and the most sensible pseudowords (fourth-order) yield the highest scores" (p. 135). So it appears that the more the subject was able to apply basic knowledge about the structure of English spelling when perceiving the pseudowords, the more accurately and completely the subject was able to report the stimulus which was presented. Miller, Bruner and Postman concluded that "it appears that context improves recognition" (p. 139).

Several studies (Aderman & Smith, 1971; Gibson, Pick, Osser, & Hammond, 1962; Reicher, 1969; Wheeler, 1970) have demonstrated that letters are easier to identify when embedded in words than when either presented alone or in non-words. This would seem to be further support for the notion that context improves recognition.

Pillsbury (1897) created non-words by deliberately altering one or more letters in the spelling of English words. This was done by either omitting one or more letters, blurring a letter by overtyping it with "x", or replacing one letter with another letter. These distortions were read by subjects as:

disgust for biagust
noxious for nxious
earth for eaxth

foreign for forengn
apricot for aprxcxt

When asked about what they had seen, most subjects did not report seeing the alteration. Only 40 percent of the omissions were detected; only 22 percent of the replacements were detected; and only 14 percent of the typeovers were detected (pp. 379 and 391).

Each of these findings is in keeping with what would be predicted on the basis of the Goodman Model of Reading (Goodman, 1967, 1982a). Meaningful texts are more central to the language than individual sentences; sentences are more central to the language than words; words are more central than non-words, letter strings or individual letters. It is possible to make non-words more like language than letter strings by providing for redundancy, a basic characteristic of language. Goodman (1971) explains that the more characteristic of language a particular piece of material may be, the easier it is for the perceiver to process.

Kohlers and Katzman (1966) used a tachistoscope to present one letter at a time for subjects to view. One group of letters presented was selected because they could be viewed as forming two separate three letter words or one six letter word (e.g., "father" could be viewed as being "fat" and "her" or as "father"; "hasten" could be viewed as "has" and "ten" or "hasten"). The letter sequences were serially presented so that each letter appeared on the same part of the viewing screen. Variables considered in this experiment were the kinds of words presented, the interval between the third and fourth letters, and the visual duration of the individual letters. Even when the time lapse between the third and fourth letter was 22 percent of the total presentation time for all six letters, the probability of detecting a single six letter word rather than two distinct three letter words was high. This research finding is consistent with the notion advanced by Bever (1973) that "One outstanding characteristic of human perception is that we tend to organize our conscious perception of the world in terms of the highest available level of organization" (p. 149). This may partially explain the consistent findings which yield positive results in favor of larger units of perception in reading.

What we know of reality "... has been mediated, not only by the organs of sense but by complex systems which interpret and reinterpret sensory data" (Neisser, 1967, p. 3). Bartlett (1932) used the term schema to describe those complex systems. Schemata represent "building blocks of cognition" (Rumelhart, 1981, p. 4). We have schemata for reading which we utilize whenever they are appropriate (Canney & Winograd, 1979).

Neisser asserts that "The existing schema, which has been formed by earlier experiences, determines what I pick up instead of adding to it" (1967, p. 42). So it is that people tend to see what they expect to see. As Neisser illustrates, "A readiness for letters rather than numbers may determine whether a subject actually sees B rather than 13..." (1967, pp. 123-124). When we read we tend to see and understand what we expect to be in the text rather than what is actually in the text. Yet perception does more than merely affirm the expectations the perceiver may have, it also provides new information. We must anticipate if we are to perceive but we cannot perceive only what is anticipated (Neisser, 1976). Those expectations which the reader has and the mind set of the reader which serves as the basis for those expectations are known as expectation and set (Haber, 1966).

Neisser maintains that "Perception is inherently selective" (1976, p. 55). What we select when we perceive is determined in part by our expectations. Yet we also do not perceive all we expect, even if confirmation of our expectations is available in our visual field. We generally sample only enough of a visual array to confirm or disconfirm our expectations. Neisser explains that"...perception is a constructive process, and visual figure, as well as verbal hypotheses, are determined by fragments and plausible alternatives" (1967, p. 118). As can be seen, perception is a complex process. The knowledge the individual brings to visual perception determines in large part the nature of that perception (Neisser, 1976).

Miller (1956) has observed that severe limitations are imposed on what we are able to perceive and remember by our visual span and the ability of our immediate memory to retain visual information. Miller suggests that the limitation on the amount of information is approximately seven pieces or "chunks" of information at any one time.

The number of random characters accurately reported from a brief visual display is normally considerably less than seven. Yet it is possible to report letters or numbers far in excess of seven characters when presented rapidly if those letters or numbers are arranged in a manner meaningful to the subject (Neisser, 1967, p. 196).

Not only is perception easier and more accurate when an individual is able to chunk, but language itself has properties which make perception of every element or character unnecessary (Smith, 1971). One such property of language is redundancy. Garner (1962) defines redundancy as the extent to which the sequence of events in language is non-random.

The perceivers' ability to organize and chunk units they perceive and the perceiver's ability to use knowledge of language to make use of the characteristic of redundancy make language units larger than individual letters easier to perceive in a visual display.

When random numerals have been tachistoscopically presented, viewers have been unable to utilize redundancy and have had difficulty chunking the numerals into larger units. The span of apprehension for numerals is consistently low and attempts to increase the span of apprehension through training have been unsuccessful (Phillips, 1954). Yet the ability to find an underlying pattern to the numerals can result in a significant increase in the span of apprehension. For example, the sequence 149162536496481 would be difficult to reproduce even after an exposure of several minutes if the viewers attempted to remember the individual numerals, "1, 4, 9, 1, 6...." Yet if the viewer identified the sequence as the first nine squares in sequence, reproduction could be accurate and complete even after a brief exposure (Neisser, 1967).

Bryden (1960) studied perceptions of tachistoscopically presented geometric shapes. Bryden compared the perception of geometric shapes with the perception of letters. He found significant differences between the ability to perceive and report letters and geometric shapes. Letters were reported with statistically significantly greater accuracy than the geometric shapes. With both types of material, however, Bryden found that subjects reported the characters in a left-to-right sequence.

Smith (1975) explains the difference in an individual's ability to perceive visual material employing differing characters or organization of characters. He says readers utilize two different sources of information when reading. One source is the author (or the printer) who provides visual information which is the ink marks available on the page (or, as in the case of this study, the images on the screen). The second source of information is non-visual information which the reader provides and which is available even when the visual information is not. This information is in the mind of the reader. These two forms of information account for the view that "reading is only incidentally visual" (Kolers, 1969, p. 8).

Design of the Study

The current study examined college readers' abilities to perceive and accurately report ten lines of print which varied in content from geometric shapes to complete sentences in English, Portuguese and Hebrew. The lines were

rapidly presented one at a time through the use of a tachistoscope.

The basic purpose of this study was to test the predictive validity of the Goodman Model of Reading regarding visual perception. The study focused on the basic question: To what extent are the subjects able to perceive and accurately report each line of print? The specific research questions addressed were:

1. What differences, if any, were evident for the number of characters accurately reported between and among the lines of print?

2. To what extent did the subjects report a meaningful language-based response for each line of print?

This study has been designed to test the predictive validity of the Goodman Model of Reading on several specific points. Among those points are:

1. the size of the perceptual unit during the reading.

2. the necessity of having a language familiar to the reader in order for reading to occur.

3. the subjects' tendency to make sense of what is presented.

4. the role of prediction in reading, particularly with regard to expectation and set.

5. the role of the reader's cognitive input when reading.

This study provides the basis for integrating knowledge being currently generated in the field of reading with knowledge which has been generated through a hundred years of research. It also provides the opportunity to test and refine knowledge which has been gained through a naturalistic form of inquiry with a framework which is more controlled; a better understanding of perception in reading is the goal.

Methodology

Subjects

The subjects were graduate and undergraduate students enrolled in the College of Education at the University of Arizona in Tucson, Arizona. These students were enrolled in courses offered through the Departments of Reading and Elementary Education at the University of Arizona.

In addition to being asked to report what they had seen after the visual presentation of each line of print, the subjects were asked to complete a questionnaire which provided personal information. This information was then used to legitimize each subject in terms of criteria which had been previously established.

Subjects participated in this study based on the following considerations:

1. They were available and present at the time the lines of print were presented to a group of subjects.

2. They were willing to cooperate fully in the completion of all tasks which were involved in the study. Subjects who were unwilling to cooperate fully were directed not to participate in the tasks involved in the study.

3. They were able to read English proficiently but not able to read Spanish, Portuguese or Hebrew proficiently. The group of subjects in this study highly proficient in reading in any of those languages was considered likely to be so small as to make statistical analysis of those results of little value. As it turned out, four subjects were eliminated because they considered themselves highly literate in Spanish, one subject was eliminated because of high reading proficiency in Hebrew and one subject was eliminated because of high reading proficiency in Portuguese.

4. They had vision which they considered to fall within normal ranges either normally or with correction. Six subjects were eliminated because they indicated below average vision which was uncorrected at the time of the study.

5. They hadn't seen or been exposed to these particular lines of print prior to their participation in this study. Three subjects were eliminated because they had seen a substantial portion of the material presented at another time.

Additionally one subject was eliminated because she had a poor and inadequate view of the screen used for presenting the lines of print.

The responses from the remaining eighty-two subjects were analyzed and formed the basis of this report.

The Lines of Print and their Presentation

A series of ten lines of print were used in the study. Two additional lines of print were used as dummy lines which were not used to gather data but allowed subjects the opportunity to adjust to the speed of presentation and to position themselves so they could have a clear view of the screen.

Each line of print was selected to provide a unique set of characters or organizational patterns.

The two dummy lines were positioned at the beginning of the sequence of presentation. All subjects saw the remaining ten lines in a standard sequence based on a random draw. The lines of print in the sequence of presentation are presented in Appendix A.

A filmstrip was made from the lines of print as presented in Appendix A. Using a TACH-X tachistoscope (Educational Developmental Laboratories), each line of print was presented one at a time to the subjects for a period of one-hundred milliseconds (one tenth of a second). Several researchers have indicated that this time was appropriate for the purposes of this study (e.g. Smith, 1971; Woodworth 1938) and such a time is consistent with the time of exposure in traditional tachistoscopic studies.

After the presentation of each line of print the subjects were allowed adequate time to record in writing what they could remember before the next line was exposed. These written records were assumed to represent the subjects perceptions for each line of print.

Scoring Subjects' Responses

The research questions on which this study is based involve two sets of considerations: the number of characters accurately reported and the degree to which each response is meaningful and language-based. A scoring system was established for each of these considerations which made statistical analysis and comparison possible. Each of these scoring systems is considered below.

For each character presented in each line of print, alloforms (alternate forms of that character) were accepted as correct responses.

To determine the number of characters accurately reported, the following scoring system was utilized:

1. One point was given for each character reported by the subject that appeared somewhere in that line of print. No point was given for any reports of a character beyond the number of times it actually appeared in the line of print.

2. One point was given each time a character appeared in the proper position in the line moving left-to-right from the leftmost character (e.g., if "g" is the third character in a row of numerals and a "g" is reported in the third position, then one point was awarded for that character). Word boundaries indicated by spaces left between characters were used as one factor in determining position.

3. One point was given for each character that occurred in the same left-to-right sequence as occurred somewhere in that line of print. A sequence was generally two or more letters in order. The only exception to that guideline was that if the leftmost character of the line was reported in the position for the leftmost character, it was awarded one point for sequence since the leftmost character represented the beginning of the sequence in English writing.

4. The maximum total number of points that could be given to any one character was three.

5. All points given for all characters reported for each line of print were added together and divided by the total number of points possible for that line to arrive at a proportional score of points received to total points possible. That proportional score has been used for the purposes of statistical analysis.

The second scoring system was designed to determine the degree to which each response was meaningful and language-based.

To determine the degree to which a response is meaningful and language-based, the following scoring system was used:

1. One point was awarded each time a letter was used.

2. One additional point was awarded for each letter when it was used as part of a sequence of three or more letters which could be part of a legitimate spelling pattern in English.

3. One point was given each time a series of letters constituted a real English word of two or more letters if they were separated by word boundaries (spaces) and three or more letters if they were imbedded in a longer sequence (e.g., letter string, other words).

4. One point was given each time three or more words formed a meaningful language unit of a clause or a sentence.

5. The maximum number of points awarded varied for each line depending on its characteristics. For those lines where the English alphabetic system was not used, a total possible point value of zero was assigned and they were not used in certain analyses.

6. All points given for all characters and combination of characters for each line of print were added together and divided by the total number of points possible for that line to arrive at a proportional score. That proportional score has been used for statistical comparisons.

Each line of print reported by each subject received two scores: one for number of characters accurately reported and one for the degree to which the subjects' responses were meaningful and language-based.

Analysis of Data

The primary method of statistical analysis which was applied to the data collected during this study was the Student's Distribution of t, which provided comparisons between pairs of lines of print. For the data collected in this study a t-test for matched pairs was used.

Throughout this study the level of significance for all statistical tests was p§.05 or lower.

The data were analyzed both quantitatively and qualitatively to gain answers to the research hypotheses which were advanced.

Prediction of Performance

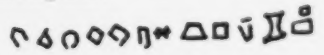
It was predicted according to the Goodman Model of Reading that the subjects would report the lines of print in the following descending order for accuracy:

1. Meaningful English sentence
2. English word
3. English pseudoword
4. Sentence of English words in mixed order
5. Mixed English/Spanish sentence
6. Portuguese Sentence
7. Series of consecutive numerals representing first nine squares
8. Lower case alphabetic characters
9. Irregular geometric shapes
10. Hebrew sentence

For the purposes of analysis, the ten lines of print were clustered into groups on the basis of each line's similarity to other lines of print in the study. A summary of the groupings for analysis and the basis for the inclusion of each line in each group is presented in Table 1.

TABLE 1

Summary of groupings for analysis.

Line	Group #	Number in Sequence of representation	Reason for Inclusion
English sentence: CAN YOU READ THIS?	1	9	Significant unit of written English
English word: TRANSLATION	1	2	Significant unit of written English
Mixed English/ Spanish sentence: THIS IS UN DESAFIO	2	4	Partial absence of cuing systems for monoliterate subjects
Mixed word order sentence: BE CAN READING FUN!	2	7	Partial absence of cuing systems
Pseudoword: CALCALADTOR	2	8	Partial absence of cuing systems
Portuguese sentence: EU POSSO LER ISTO	3	10	Alternate language form using same alphabet as English
Random alphabetical characters: azqrdgfdeomslp	4	1	Randomly arranged characters known to subjects
First nine squares in consecutive order: 149162536496481	4	3	Characters likely to appear to be randomly arranged and are characters with which subjects are familiar
Irregular geometric shapes: 	5	5	Characters not drawn from English writing system
Hebrew sentence: אני יכול לקרא עברית	5	6	Characters not drawn from English writing system

Findings

Based on the Goodman Model of Reading, hypotheses were designed to reveal information which would reflect the usefulness of the Goodman Model as an accurate and predictive instrument.

The findings were consistent with what had been predicted. The more like language or more central to language a line of print was, the more accurately and completely it was reported. The more familiar the characters in a line of print were to the subjects, the more completely and accurately those characters were reported.

The predicted descending order for accuracy of reports proved to be completely accurate. Moving down the predicted order for accuracy of report, each line of print proved to be reported with significantly less accuracy then the line which preceded it. The formation of groups of lines for analysis on the basis of similarities of lines within each group seems to have been appropriate based on the mean accuracy scores derived from analysis of the reports provided by the subjects. A summary of the mean accuracy scores for the individual lines of print and for the groups as they had been formed is presented in Table 2.

TABLE 2

Mean accuracy scores for each line of print.

Line of Print	Number of Subjects	Mean Accuracy Scores	Group Mean Accuracy Score
English sentence	82	.951	
English word	82	.882	.918
English pseudoword	82	.680	
Mixed word order sentence	82	.531	
Mixed Spanish/English sentence	82	.450	.553
Portuguese sentence	82	.309	.309
First nine squares in consecutive order	82	.179	
Random lower case alphabetical characters	82	.156	.172
Irregular geometric shapes	82	.015	
Hebrew sentence	82	.004	.01

Each of the five groups was statistically significantly different from each of the other groups. The two lines of print which comprised Group 1 were reported with significantly greater accuracy than any other of the lines of print. Of particular interest from the perspective of the Goodman Model of Reading is that the English sentence was reported with statistically significantly greater accuracy than the English word. A summary of the results of that analysis is presented in Table 3.

TABLE 3

T-test between Accuracy of Reports for English Sentence and Accuracy of Reports for English Word.

Mean accuracy score for English sentence	= .95
Mean accuracy score for English word	= .88
t-statistic	= 2.25
degrees of freedom	= 81
Probability of error	= .013

Goodman has discussed the operation of three cuing systems in reading: the semantic, the syntactic and the graphophonic systems (Goodman, 1970). Group 2 included lines of print which had a partial lack of cuing systems for the subjects in this study. In keeping with predictions made on the basis of the Goodman Model, the lines of print in this group were reported with significantly less accuracy than in Group 1 but with significantly greater accuracy than Groups 3, 4 or 5.

The number of characters accurately reported for Group 3, which was comprised of only the Portuguese sentence, was significantly greater than the number of characters accurately reported for Groups 4 and 5. While the Portuguese sentence was reported with significantly greater accuracy than the random alphabetical characters ($t=8.533$, $P\S.0001$), there was no significant difference between the reports for the two lines of print when compared for being meaningful and language-based ($t=.41$, $p=.693$). The accuracy of the reports for the Portuguese sentence may have been increased because the subjects were able to apply knowledge of word boundaries and spelling patterns. Only two subjects reported an English word or phrase for the line of Portuguese. For the line of random alphabetical characters, five subjects reported English words, seven subjects reported letter strings which contained English words embedded within them and an additional six subjects reported

letters in a legitimate English spelling pattern. It seems likely that the subjects identified the Portuguese sentence as a foreign language and were therefore able to accept and report non-English spellings. Yet they were unable to categorize the line of random alphabetical characters in such a way and, consequently, perceived the line as being more regular and predictable than it really was. That is, the subjects utilized non-visual information to compensate for visual information which was irregular and fading quickly from their visual memories.

Overall, twenty-two percent of the subjects used a regular pattern, based on their knowledge of English writing, in reporting this line of print. Such a tendency to report a predictable pattern for the characters which were presented supports the idea that the viewer is actively cognitively involved in the process of perception. Additionally, the evidence supports the view that a reader makes predictions about what is to be seen and actively engages in selectively attending to (i.e., sampling) the visually available material to either confirm or disconfirm those predictions.

Group 4 was comprised of two lines of print: numerals representing the first nine squares in consecutive order and random lowercase letters of the alphabet. None of the subjects identified the underlying pattern of the first nine squares. Yet the numerals in that line were reported with statistically greater accuracy than the letters in the line of lowercase letters. This is consistent with predictions drawn from the field of cognitive psychology, since the subjects had to apply schemata and search through a set of only ten characters for the numerals while the set of letters of the alphabet called for application of schemata for twenty-six characters. The larger set of characters resulted in the lower accuracy scores. It took the subjects longer to decide on the characters presented from the larger set than from the smaller set, even though both sets were well known to all the subjects.

The English word (TRANSLATION) was reported with significantly greater accuracy than the English pseudoword (CALCALADTOR). Yet the reports of the two lines of print were not significantly different when comparing the degree to which the two lines were reported in terms of the reports being meaningful and language-based. Fifty-two percent of the subjects reported the pseudoword as a real English word, most commonly as "CALCULATOR" but also as "CALENDAR", "CANCELLATION" and "CALCULATION". Ninety-eight percent of all responses for this line were valid English spelling patterns.

Only one subject reported the letters "DT" as adjacent in this line of print. Nineteen other subjects reported the two letters in the sequence but separated them with a vowel. In English spelling the letter "d" and "t" appear together in a relatively small number of words (e.g. width, breadth). It seems that all but one of the subjects in this study applied nonvisual information regarding spelling patterns of English and rejected the "DT" combination based on that information.

None of the subjects accurately reported the line of Portuguese, the line of Hebrew or the line of mixed English/Spanish. It is interesting that the individuals who reported themselves as being proficient in reading Spanish (who were consequently eliminated from the study) were able only to recognize the presence of Spanish in the English/Spanish line but not to report the Spanish that was in the line. The one individual eliminated because of proficency in reading Hebrew was unable to report the characters in the line, reporting only "Hebrew language" for that line. Yet she later read the line aloud in Hebrew and translated it into English for a group of subjects.

These occurrences support the concepts of "recognition" and "initiation" of reading in the Goodman Model of Reading. What has happened in each of these cases is that apparently the viewers recognized the reading tasks as being in a specific language other than English. Yet the time was too brief to initiate the reading and activate appropriate schemata before the visual memory of the line faded.

The evidence was quite strong throughout the reports that subjects had expectations of what might be presented and then minimally sampled the line of print in arriving at meaning.

For example, for "This is un desafio," the following reports were received:

The sun is yellow.	*This is end
The sun is down.	*This is an detail.
in the umbrella	This is the description.
More than double	This is an update.
This is the	This is understood.
This is an umbrella	This is on?
	*This is sun hello.

(*An asterick is used to indicate sequences which are unacceptable to speakers of English.)

For "Be can reading fun" the following reports were received:

Be careful tonight.
*Be reading fun.
*Be is reading fun
Be a man
*Be - reading can be fun
*Be can counting fast
Be a dog
Reading can be fun?
Reading can be fun]
Can reading be fun?
Boy, can reading be fun.
Can you be reading this?
Reading can be fun. (reported by three subjects)

Be a reading test
Be careful
*Be a reading fun
*Be reading is fun
*Be a reading chart.
*Be can regard
*Be can be fun
He can read
Can't be reading
I'm reading
We can be reading

In each of the above examples it seems that the subjects did not perceive each letter or character in the line of print but sampled the line. They then provided a report that was consistent with the set and expectation of the subjects and also consistent with the characters which they sampled from the fading memory image.

The line of geometric shapes and the line of Hebrew were the most difficult for the subjects to perceive and report. This is believed to be because the subjects did not have previous experience with the characters or with any organizational structure (schema) to which they could be related. The subjects had little, if any, prior knowledge of the characters in these two lines of print. They were, therefore, unable to apply approrpiate non-visual information in perceiving those characters. The subjects' reports for these two lines of print highlight and emphasize the roles of both visual and non-visual information in visual perception.

Discussion

The reports of eighty-two subjects were analyzed quantitatively and qualitatively for the purposes of answering two research questions which encompassed ten research hypotheses. Specifically, the analyses focused on the accuracy of the reports in relation to the types of characters used in each line of print, the manner in which those characters were organized and the degree to which the reports were meaningful and language-based.

The following is a summary of conclusions based on the findings of this study:

1. The unit of perception in reading may be determined by the setting in which the reading occurs and the purposes of the reader. Yet the findings of this study suggest that the unit of perception in reading is either the clause or the sentence when they are

available, not any smaller graphic or linguistic unit. This study clearly established that the English sentence and the English word were reported with significantly greater accuracy than all other lines of print. This study also confirmed that the English sentence was reported with greater completeness and accuracy than the English word.

2. The more knowledge a reader is able to apply to written materials in terms of the structure and redundancy of language, the greater the speed and accuracy of perception in reading that material.

3. Prior knowledge of the written form of a language (e.g., English, Spanish, Portuguese, Hebrew) is necessary to perceive that written language quickly and accurately. This conclusion is based on the results of the written reports for the lines of English, the line of mixed English and Spanish, the line of Portuguese, and the line of Hebrew. Only the English sentence and the English word were reported with accuracy that approached being complete. As the lines became less characteristic of written English, the subjects' ability to report them completely and accurately declined sharply.

4. The expectation and set of the individual perceiver influences and determines what is perceived. This was strongly confirmed. through the qualitative analysis of the subjects' reports.

5. Readers are not totally dependent on the visual stimuli in perception.

6. Perception in reading involves the processes of predicting, sampling and selecting. This conclusion was substantiated through qualitative analyses of individual reports which were inaccurate but reflected an orientation toward meaning or regularity.

7. What is perceived during a single visual fixation in reading depends on the nature of the characters utilized, the organization of those characters in the visual field and the readers' schemata. This is an overriding conclusion established through analysis of the reports for each line of print and throughout every statistical test conducted during this study.

8. Reading cannot occur without the presence of all three cuing systems. This has been clearly established through the data gathered from reports for the English sentence, the English word, the mixed

word order sentence, the line of English and Spanish, and the line of Portuguese. As the lines became more like written English by providing closer approximations to natural language with all three cuing systems available, the scores for both accuracy and meaningfulness increased by significant degrees.

9. Readers attempt to organize, systematize and find meaning in what is perceived.

10. The individual utilizes both visual and non-visual information when engaged in visual perception. When the individual is unable to supply non-visual information, perception becomes difficult if not impossible.

11. When characters are presented for which the reader has no existing mental organizational framework, visual perception is inaccurate and incomplete. The line of irregular geometric shapes and the Hebrew sentence fall into this category.

12. The reader must recognize the reading task to be performed and initiate the appropriate behavior for reading to occur. Several instances occurred in this study of readers who failed to recognize and initiate appropriate reading behavior in spite of proficiency in reading the language.

13. Readers were able to perceive whole, meaningful language units with greater speed and accuracy than individual letters or words. This is consistent with the work of earlier researchers (e.g., Cattell, 1886) on this point.

Evidence from this study, taken with evidence from Gollasch's investigation (1980) of perception of errors imbedded in a meaningful passage, strongly indicates the validity of the Goodman Model of Reading for both describing and predicting reading behavior. Such evidence strongly suggests that meaning is the most central concern influencing perception in reading.

This study has demonstrated that a model of reading which has been developed through analysis of reading behavior employing connected text can serve as an accurate instrument for predicting and describing visual perception in non-connected material. This study therefore serves as a step toward integrating research findings from such traditional methods of studying reading as those using a tachistoscope with knowledge being generated through the study of reading connected texts.

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Appendix

THE LINES OF PRINT IN THE FORM AND SEQUENCE OF PRESENTATION

? + ? + ? + ? + ? + ? + ? + ? + ? + ?

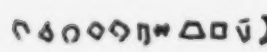
= * = * = * = * = * = * = * = * = *

azqrdgfdeomslp

TRANSLATION

149162536496481

This is un desafio.



אני יכול לקרא עברית

Be can reading fun!

CALCALADTOR

CAN YOU READ THIS?

Eu posso ler isto.

= * = * = * = * = * = * = * = * = *

? + ? + ? + ? + ? + ? + ? + ? + ? + ?

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